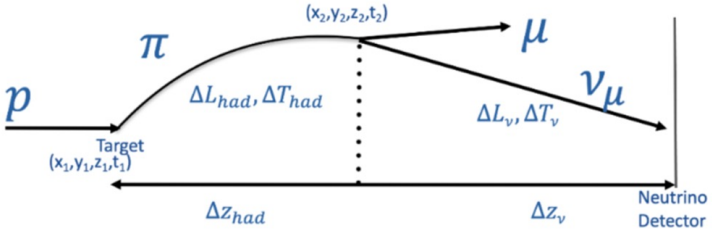
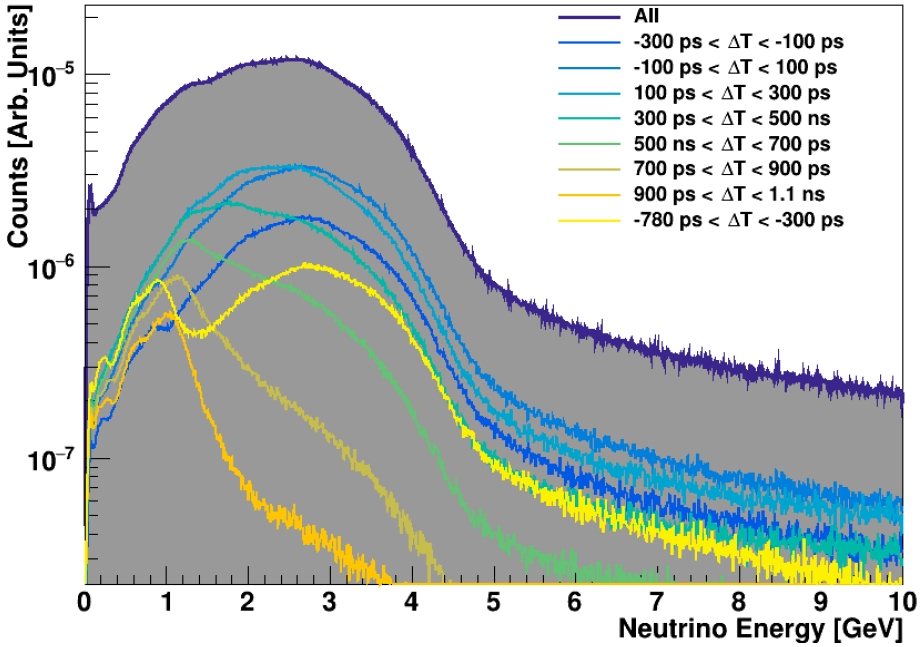
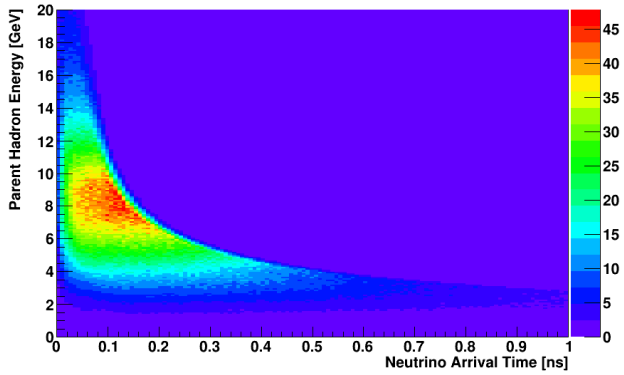
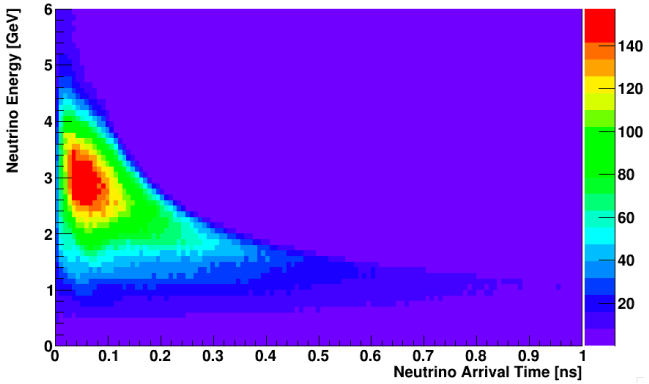
Neutrino Beam Timing – Stroboscopic Approach







Arrival time difference between neutrinos from relativistic hadrons and neutrino from hadron of energy E



Relative neutrino arrival times versus neutrino energies for all neutrinos with simulated data of the LBNF beam

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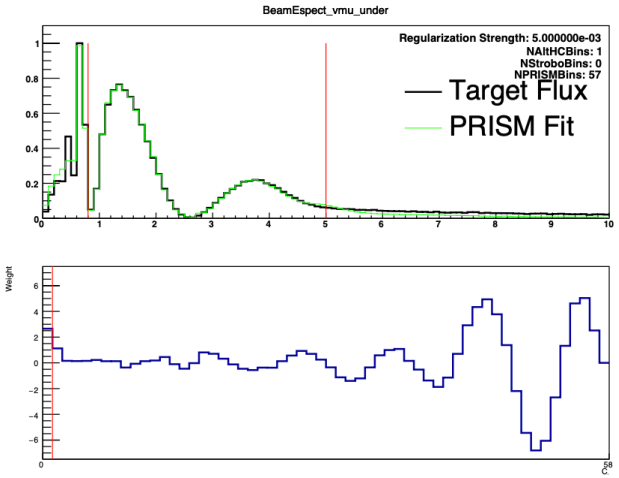
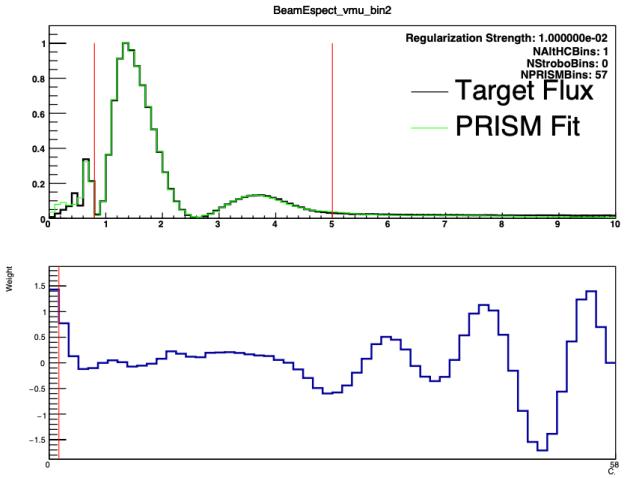
Motivation

Number of Near Detector events = Flux • Cross section • Detector effects

Number of Far Detector events = Flux • Oscillation probability • Cross section • Detector effects

- If both flux and cross section have uncertainties, cannot unambiguously tell if we have both correct in models or both wrong in ways that result in approximately correct event rate prediction
- **Stroboscopic approach – can be applied to both Near & Far detectors**
  - Oscillated time integrated spectrum of Far Detector can be fitted to PRISM and Stroboscopic approaches in Near Detector
  - Can provide Far Detector oscillated time slices





PRISM fits to oscillated Far Detector time bins

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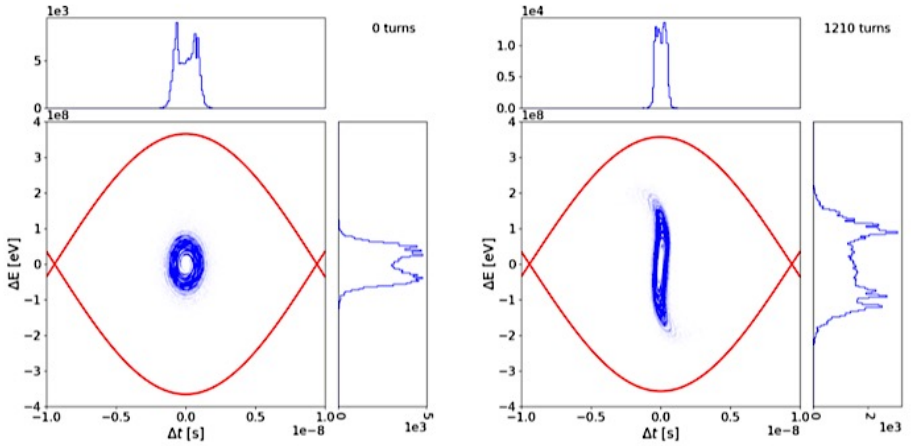
Application of Stroboscopic Approach

Application requires efforts in:

- Creation of short (O(100 ps)) proton bunch length
- Detectors with fast timing to get equivalent time resolution
- Synchronization b/w time at detector & time of bunch-by-bunch proton

Precision timing in DUNE ND – possible with minor upgrades, in FD later design modification possible

Use bunch rotation at MI to create Narrow Bunches:



Minimal bunch length of 330 ps occurs ~ 1210 revolution

- ANNIE equipped with Large Area Picosecond Photodetectors (LAPPDs) → better vertex reconstruction, improved background rejection → together with precision timing in beam delivery and time synchronization tools developed, first proof of principle possible with ANNIE
- With tools developed for time synchronization, precision timing can be applied to future oscillation experiments with fast detectors - there is an excellent opportunity here to think about fast timing for LAr-TPCs